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METHODS FOR FORECASTING OFFICER LOSS RATES

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METHODS FOR FORECASTING OFFICER LOSS RATES

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FOREWORD

This research and development was conducted in response to Navy decision coordinating paper Z1187-PN (Computer-based Manpower Planning and Programming) under subproject PN.02 (Officer Personnel Management Models) and the sponsorship of the Deputy Chief of Naval Operations (Manpower, Personnel, and Training) (OP-01). The objective of this subproject is to develop a set of user-oriented, computer-based models and data bases to assist in the development of a Navy officer force that meets the requirements for officer manpower.

This report describes a major component of the structured accession planning system for officers (STRAP-O), the officer retention forecasting model (ORFM). ORFM is a set of integrated time-series and econometric models that produce loss rate forecasts for a 7-year time horizon. It provides the capability to test the sensitivity of the officer force structure to alternative compensation plans and loss rate scenarios.

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SUMMARY

Problem

The prediction of officer losses is an important ingredient in the development of accession and promotion plans and the formulation of personnel policies. Officer losses are difficult to predict because they are influenced by numerous and uncertain factors. Since the uncertainty associated with these factors increases with time, methods used to forecast losses should explicitly incorporate uncertainty.

Purpose

The purpose of this report is to describe alternative techniques used to forecast officer loss rates. These techniques are currently embedded in the officer retention forecasting model (ORFM).

Forecasting Loss Rates

Two statistical approaches generally used to forecast aggregate-level loss rates are econometric and time-series models. The econometric approach requires the formulation and estimation of a behavioral model, while the time-series approach requires only historical loss rates. Econometric models can estimate the effects of changing policies, but are often subject to many biases. Although time-series models cannot measure the influences of policy, they often produce the most accurate short-term forecasts. ORFM utilizes both time-series (minimum absolute deviation regression and historical weighting) and econometric (cost-of-leaving) approaches. The cost-of-leaving model is used to estimate the effects of compensation policies.

Uncertainty is incorporated through the implementation of a "wear-off" function, which provides for the migration over time of the loss rate forecasts to an historical average. The purpose of the wear-off function is to avoid the potential for large forecasting errors that may result from loss rate projections that are at historical extremes. The period of migration is dependent upon the variability of the historical rates, as measured by the coefficient of variation and the mean time between "crossover."

Applications

ORFM can produce loss rate forecasts disaggregated by community, length-of-service, and pay grade over a 7-year horizon. These forecasts may be altered by imposing a pay change, net of anticipated inflation. For example, the effect of the aviation officer continuation pay on pilot loss rate forecast is presented. This pay contributed to the historically low loss rate in 1982. ORFM produces pilot loss rate forecasts for later years that migrate upward to the historical average via a 4-year wear-off period.

Conclusions

Forecasting loss rates requires both a statistical technique and a strategy to incorporate uncertainty. Explicit recognition of uncertainty is important because loss behavior is volatile and subject to many external influences. ORFM has been formulated with these characteristics in mind.

CONTENTS

	Page
INTRODUCTION	1
Problem and Background	1
Purpose	1
FORECASTING LOSS RATES	1
The Structure of Navy Officer Losses	1
An Overview of Forecasting Techniques	2
Forecasting Techniques in ORFM	3
Minimum Absolute Deviation (MAD) Regression	3
Historical Weighting (HW)	4
Cost of Leaving (COL) Model	5
An Overview of Multiperiod Forecasting	6
Multiperiod Forecasting in ORFM	6
Data Used by ORFM	8
APPLICATIONS	8
CONCLUSIONS	13
REFERENCES	15
DISTRIBUTION LIST	17

INTRODUCTION

Problem and Background

The Navy officer manpower system is characterized by a set of administrative rules and procedures that govern the internal flow of personnel. Through accession, promotion, and related policies, officer manpower managers can directly shape the size and internal structure of the force. One important personnel flow, however, is not directly controllable by the manager. This flow relates to the movement of personnel from within the system to the external labor market (i.e., losses). The prediction of losses is probably the least understood of all personnel flows because of the variety of factors that ultimately determine its extent and timing. An understanding of these factors, combined with the ability to forecast the resulting flows accurately, is essential to officer force management.

Two fundamental issues are involved in forecasting officer losses. The first issue relates to the choice of forecasting technique. By means of historical validation and related testing procedures, a technique can be selected from a set of techniques based on forecast accuracy. The technique should be evaluated on its accuracy vis-à-vis alternative techniques and not necessarily in terms of its underlying methodology.

The second, and less obvious, issue relates to forecast uncertainty. Uncertainty is inherent in every forecast situation. However, in long-term forecasting, it is especially important to incorporate uncertainty explicitly into the forecasting methodology. In many forecast situations, the treatment of uncertainty is far more crucial than the choice of the technique.

Based on the above, an officer retention forecasting model (ORFM) has been developed to forecast Navy officer personnel losses. ORFM, which consists of a set of integrated models, is embedded in the structured accession planning system for officers (STRAP-O) (Rowe, 1982). Within the STRAP-O system, the manager is allowed to influence loss rate forecasts either through alternative pay policies or through the selection of the forecasting technique. ORFM provides STRAP-O with the ability to test the sensitivity of manpower plans to alternative loss rate scenarios.

Purpose

The purpose of this report is to describe the choice of technique and related methodology incorporating uncertainty in the context of an officer loss forecasting model. Illustrative forecasts are also provided.

FORECASTING LOSS RATES

The Structure of Navy Officer Losses

In ORFM, a loss rate is defined as total losses during a fiscal year occurring in a particular "cell," divided by the inventory in that cell at the beginning of the fiscal year. A cell refers to the intersection of a particular community, length-of-service (LOS), and pay grade. A total of 23 officer communities are identified--5 unrestricted line (URL), 7 restricted line (RL), 8 staff corps (STF) and 3 limited duty officer (LDO) communities. LOS, which is measured by an officer's year group, ranges from less than 1 year of service to 30 years or more. Pay grades include 6 due course and 3 fail-select grades, for a total

of 9. Thus, for each year, ORFM produces a total of 6417 loss rate forecasts ($23 \times 31 \times 9$), one for each cell. Of course, many of the cells are empty in the sense that the corresponding beginning inventories are zero.

Losses and loss rates are composed of flows from a particular community. When the flows go from one community to another, they are known as "community changes"; when the flows leave the Navy, they are known as "strength losses." The aggregated loss rates forecasted by ORFM include both types of losses. Community changes are not losses to the external labor market; however, from a community manager's point of view, a loss to that community is equivalent to a strength loss. For the receiving community, community changes obviously represent gains. Intracommunity cell losses, such as the result of a promotion to a higher pay grade or losses to a cell due to "aging" (moving from one length of service interval to the next), are not considered a loss by ORFM.

Strength losses may be voluntary or involuntary. Voluntary losses occur when officers resign by choice; and involuntary losses occur through death, discharge, or, in the case of reservists, release from active duty. Retirements, however, may be voluntary or involuntary. Because of the official "up-or-out" policy of the Navy, some officers are forced to retire. For example, officers who have twice failed selection for promotion to the rank of commander and captain are involuntarily retired. Moreover, many officers may voluntarily retire in anticipation of forced retirement. Unfortunately, given the available data, voluntary and involuntary retirements cannot always be distinguished.

Since compensation and related variables will influence only voluntary decisions, it is necessary to distinguish between voluntary and involuntary losses. If the voluntary fraction of the total loss rate is relatively low, then changes in compensation will be relatively ineffectual in affecting changes in loss rates. Note that most community change losses are institutionally determined and hence will not be influenced by economic variables.

The forecasting of voluntary loss rates based on economic variables is further hampered by a definitional problem associated with LOS. Within STRAP-O, an officer's LOS is measured by year group, which is the date used to reflect the current precedence of an officer for promotional purposes. Typically, for the due-course officer, year group will be the fiscal year of first commissioning. However, for pay purposes, the appropriate date to measure LOS is pay entry base date (PEBD). However, since PEBD measures LOS based on total service in any of the uniformed services (active or inactive, enlisted and commissioned), it is not entirely appropriate to relate loss rates, which use LOS based on year group, to military compensation variables. The alternative is to relate PEBD-based loss rates to military compensation variables and then translate the resulting forecasts into a year-group-based measure. ORFM, however, uses year-group-based loss rates.

An Overview of Forecasting Techniques

There are two general statistical approaches to forecasting loss rates--econometric and time-series modeling. The econometric approach generates forecasts on the basis of a theoretical model whose parameters are estimated via statistical analysis of historical data. Typically, the dependent variable (e.g., loss rates) is related to a set of independent variables (e.g., military and civilian pay) using a regression model. The resulting parameter estimates are then applied to forecasts of the independent variables to generate forecasts of the dependent variable. The major difficulty with this approach is the high potential for forecast bias. The underlying model may be misspecified, the parameters may be misestimated, and, most importantly, forecasts of the independent variables may be inaccurate. The principal benefit of econometric forecasting lies in its

ability to estimate the effects of policy variables. For example, the effects of a new compensation initiative on loss rates may be estimated.

The time-series approach uses only one independent variable; namely, time. The most simplistic time-series model is the naive model, which states that the next period's forecast is equal to this period's forecast (or historical value). There are more complex time-series techniques, such as Box-Jenkins, but the important point to note is that time-series models are unable to capture the effects of changing policy directly. However, when policies do not radically shift over time, experience has shown that time-series models often produce more accurate forecasts than do econometric models.

Econometric and time-series models are stochastic approaches to forecasting. Stochastic means probabilistic; that is, the forecasts generated by stochastic models are point estimates of the mean of a probability distribution. In theory, the appropriate way to state forecasts in stochastic models is in terms of intervals rather than a single number (for example, the true forecast loss rate lies between 0.05 and 0.10 with a confidence level of 95%). In practice, most forecasting systems require point estimates as a managerial necessity. STRAP-O utilizes point estimates of loss rates because interval estimates cannot be implemented in the context of the current manpower management environment.

Forecasting Techniques in ORFM

ORFM utilizes two time-series techniques to forecast loss rates: minimum absolute deviation (MAD) regression and historical weighting (HW). These techniques do not require the disaggregation of loss rates into voluntary, involuntary, and community change components since time-series models are nonbehavioral. The econometric model implemented in ORFM is a variant of the cost-of-leaving (COL) model (Warner, 1979).

Minimum Absolute Deviation (MAD) Regression

MAD regression is a technique that minimizes the sum of the absolute values of the errors between historical loss rates and loss rate estimates. The MAD approach uses 3 years of historical data to forecast the fourth. Let LR^t = loss rate in year t (the subscripts for community, pay grade, and LOS are omitted for clarity). The following equation is estimated:

$$\hat{LR}^t = b_0 + b_1 LR^{t-1} + b_2 LR^{t-2} + b_3 LR^{t-3} \quad (1)$$

where b_0, b_1, b_2, b_3 are regression coefficients. With historical data available from 1969 through 1982, MAD is a four-variable, 11-observation regression that minimizes

$$\sum_{t=1972}^{1982} | \hat{LR}^t - LR^t | \quad (2)$$

Once the regression coefficients are estimated, MAD applies these coefficients to the 3 most recent years to derive the loss rate estimate of the first forecast year. For example, if MAD estimates $b_0 = 0.035$, $b_1 = 0.3$, $b_2 = 0.2$, and $b_3 = 0.1$, the 1983 forecasted loss rate would be

$$\hat{LR}^{1983} = 0.035 + 0.3LR^{1982} + 0.2LR^{1981} + 0.1LR^{1980}. \quad (3)$$

Note that MAD is a pure time-series technique that requires no managerial inputs. Bres and Rowe (1979) evaluated alternative time-series techniques and found that MAD produced the minimum forecasting error. Computationally, MAD may be formulated as a linear programming minimization problem (Charnes, Cooper, & Ferguson, 1955).

Historical Weighting (HW)

Unlike MAD, the HW technique derives forecasts from arbitrarily weighting historical loss rates. Essentially, the manager places a weight, between zero and one, on the most recent year of historical data. HW then calculates weights to be placed on the earlier years. The total of all weights, of course, will be one. The actual weights to be placed on each year of historical data will depend upon the weight placed on the most recent year and the number of years of available data.

Let:

n = Number of years of historical data, and

$w(yr)$ = Weight placed on the data from year "yr."

If data are available from 1969 through 1982, then $n = 14$. Assume, for example, that the manager desires to place a weight of 0.5 on historical data for 1982:

$$w(1982) = 0.5.$$

The first step in determining the weights to be placed on the earlier year is to solve the following equation for the parameter α :

$$\left(\frac{1}{n}\right)^\alpha = w(1982) \quad (4)$$

Equation 5 results from taking logarithms of both sides of (4), where $n = 14$ and $w(1982) = 0.5$:

$$\alpha \log \frac{1}{14} = \log (.5). \quad (5)$$

Dividing by $\log (1/14)$, the solution for α is obtained:

$$\alpha = \frac{\log (.5)}{\log (1/14)} = .26. \quad (6)$$

The next step is to solve for the remaining weights:

$$w(1981) = w(1982) - (1/2)^\alpha = .099$$

$$w(1980) = w(1981) - (1/3)^\alpha = .067$$

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$$w(1969) = w(1970) - (1/14)^\alpha = .019.$$

It can be shown, that, by using this simple procedure, the weights will sum to 1 and decline at a decreasing rate. Table 1 shows the values of various weights, assuming historical data are available from 1969 through 1982.

Table 1
Historical Weighting (HW) Technique Weights

Weights on most recent year (1982) ^a	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
1.00	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
0.75	.058	.036	.026	.021	.017	.015	.013	.012	.011	.010	.009	.008	.008
0.50	.099	.067	.052	.043	.037	.033	.029	.027	.024	.023	.021	.020	.019
0.25	.109	.085	.072	.064	.058	.054	.050	.047	.045	.043	.041	.039	.038

^aDetermined by management.

Cost of Leaving (COL) Model

In recent years, a number of econometric models have been formulated and estimated to predict reenlistment behavior. Most of these efforts have restricted their attention to enlisted personnel and involved variations of the "cost-of-leaving" (COL) model.

The COL model is a two-step process. In step 1, the model estimates the COL the Navy at various stages of a typical military career. This COL may be defined as the present value of the monetary returns from remaining in the Navy for one more period and then making the optimal stay or leave decision, minus the present value of the monetary returns from leaving the Navy immediately. In step 2, the model relates these COL estimates to voluntary loss rates via some form of logit regression. Analysis of these regression relationships allows the effects of various types of pay changes on voluntary loss rates to be estimated. These effects are stated in terms of voluntary loss elasticities. A voluntary loss elasticity is defined as the percentage change

in voluntary loss rates that results form a one percent change in COL. Therefore, given a specific pay scenario, the resultant voluntary loss rates can be forecasted.

As discussed previously, STRAP-O requires total loss rates rather than voluntary loss rates. Therefore, once voluntary loss rates are forecasted by the COL model, weighted averages of historical involuntary and community change loss rates must be added to obtain total loss rate forecasts.

A complete discussion of all of the intricate details of the COL model is beyond the scope of this report. (For a discussion of such models, see Warner (1979).) A number of implicit assumptions underlie the COL methodology. One noteworthy assumption is that military personnel react to contemporaneous changes in military compensation. In contrast, current changes in compensation may possibly affect expectations about future changes in compensation, and changes in voluntary retention rates may occur through these expectations.

Another important point to note is that, in a logistic model, the voluntary loss elasticity will be a function of the base loss rate. This is because elasticities are stated in terms of changes in voluntary loss rates, from a base rate, that results from changes in the COL. Thus, a starting point (the base loss rate) is required before these changes are applied. Most studies use the most recent year of historical data as the base period, although other options may be just as reasonable. For example, a weighted average of the loss rates from the three most recent years could be chosen.

An Overview of Multiperiod Forecasting

In multiperiod forecasting using stochastic models, there is a critical but often ignored issue relating to forecast uncertainty over time. The uncertainty associated with a forecast will be an increasing function of the time interval between the current and forecast periods. It is not entirely clear how to deal with this problem. One approach is to assume that the first period's forecast will remain constant over the entire planning horizon. A second approach is to view forecasting within a simulation context; that is, a first-period forecast is generated that, in turn, is used as data in generating a second-period forecast, and so on. This approach is often called dynamic forecasting. A third approach is to assume that, other things being equal, the forecast value has a tendency to migrate or "wear off" over time to some historical average, especially if the initial forecast value represents either extreme of an historical range of values. This strategy is essentially conservative in that, in the absence of overriding knowledge, forecasts (of loss rates) should be close to historical averages as uncertainty (time) increases. ORFM implements this latter approach for reasons discussed in the next section.

Multiperiod Forecasting in ORFM

The purpose of ORFM is to produce a set of loss rate forecasts for each relevant cell over a 7-year time horizon. The loss rate forecasts include both strength and community change losses. The basic approach is to generate first-year forecasts of loss rates via either a time-series or an econometric model. In years 2 through 7 of the forecast horizon, a "wear-off" function is implemented whereby the first year forecasts migrate to a set of baseline loss rates. In any year of the 7-year horizon, the loss rate forecast may be altered via a real (inflation adjusted) change in military pay.

There are two primary sets of reasons for implementing a wear-off function in ORFM. One set is related to the increasing uncertainty over time associated with the

forecasts; and the other, to the "absolute pay" hypothesis. As noted previously, a conservative strategy is one in which the forecast tends to an historical average when uncertainty is relatively high. This approach, which is analogous to the process of discounting, is particularly amenable to forecasting loss rates because of its inherent stochastic nature. Some of the more important variables that ultimately determine the number of losses include civilian and military pay and benefit levels, civilian unemployment rates, promotion opportunities, and sea-shore rotation requirements. These variables are difficult to forecast, and their influence on loss behavior is difficult to estimate. Therefore, a conservative strategy is one in which, in the absence of overriding information, loss rates tend to a "baseline."

Consider, for example, the scenario in which a large increase in relative military pay occurs in (forecast) year 1 and no relative increase occurs in years 2 through 7. A relative increase occurs when military pay rises faster than does civilian pay. Therefore, under this scenario, an econometric model that is based on relative pay levels would predict loss rates to decline in year 1 and remain constant in years 2 through 7. Thus, if the forecast of loss rates in year 1 were abnormally low relative to some historical average, the forecasts would be abnormally low for the entire planning horizon. Given the assumption that officers respond to relative pay levels, this is not a conservative forecasting strategy. Measurement errors in relative pay and the effect of unspecified variables are sufficient reasons to adopt a conservative strategy.

The basic hypothesis stated above is that military personnel are less concerned with their absolute level of income than their income relative to their civilian counterparts. An alternative speculation presented here is that present loss behavior is not only influenced by present levels of relative income but also by levels of real income attained in previous periods. Essentially, the argument presented above is that military personnel expect a certain level of real growth in their incomes. This expectation is based primarily upon the recent history of real income growth. If a growth rate in real income is not sustained, loss rates will tend to rise even if the relative level of income is held constant. This "absolute pay" hypothesis is essentially a variation of Duesenberry's (1952) theory of consumption applied to labor force behavior.

From a strategic point of view, manpower managers find a conservative forecasting procedure advantageous. If current loss rates are extremely high or low relative to history, the constant projections of such extremes over a long planning horizon can result in substantial long-term personnel shortages or surpluses. By "hedging" (i.e., retreating to some average value over the long run), the manpower manager can avoid very large forecasting errors. Relatively small errors can be ameliorated with special programs or incentives; large errors are much more difficult to overcome.

Given the available historical data, it would be very difficult, if not impossible, to empirically derive a general form of a wear-off function. This is particularly true since a component of the phenomenon to be captured--forecast uncertainty--is difficult to quantify. Although the form of the wear-off function in ORFM is arbitrary, it has the virtue of being explicit. Consequently, the development of empirical data bearing on the problem can be used to design improved versions.

The procedure to calculate loss rates and loss rate wear-off for forecast years 2 through 7 is as follows. For each cell, a baseline loss rate is calculated. Currently, the baseline is a simple unweighted average of all historical loss rates. The first year forecast is generated with a time-series or econometric model, as discussed in the previous section. In years 2 through 7, the first year loss rate forecast migrates to the

baseline loss rate. The time period of wear-off (i.e., the number of years required for the first year forecast to migrate to the baseline) depends upon the coefficient of variation and the mean time between "crossover" of historical loss rates.

The coefficient of variation is defined as the standard deviation divided by the mean of the historical rates. The larger the coefficient, other things being equal, the greater the volatility of loss rates, and the shorter the wear-off period.

The mean time between "crossover" is defined as the average time, in years, between movements from below the baseline to above the baseline, or vice versa. The longer the period of crossover, other things being equal, the longer the period of wear-off.

The movement from the first year forecast to the baseline is in a straight line. If the wear-off period is 5 years, for example, then one-fifth of the difference between the baseline and the first year forecast is made up in years 2, 3, 4, 5, and 6. In year 7, the loss rate forecast remains at the baseline loss rate. Thus, in this example, the loss rate forecast would be equal to the baseline loss rate in both forecast years 6 and 7.

Suppose that the manager desires to implement a real change in military compensation in years 2 through 7. As discussed in the previous section, to forecast the effect of compensation on loss behavior requires the knowledge of a base loss rate. The procedure in ORFM is to apply the wear-off function first, which generates a loss rate for a particular forecast year, and then apply the effects of the pay change. Note that the effects of a pay change and the wear-off function may be in opposite directions. For example, if the first year loss rate forecast is below the baseline loss rate, the loss rate forecast will rise during years 2 through 7 due to the wear-off. However, a pay increase in any year will cause a decline in the loss rate. Therefore, the change in the loss rate from one year to the next is due to the net effect of wear-off and pay change. The loss rate may conceivably rise in a year of a pay increase if the increase in the loss rate due to the wear-off outweighs the decrease in the loss rate due to the pay increase. The following section illustrates this phenomenon by applying the ORFM model to real data.

Data Used by ORFM

The historical data used by ORFM are derived from the attrition data base (ADB), a longitudinal file of all Navy officers on board from 1969 to the present. From these data, it is possible to generate yearly loss rates for each STRAP-O defined community. Moreover, regardless of the type of loss as encoded by the loss code, losses to the Navy occurring prior to the fulfillment of the minimum service requirement (MSR) are assumed to be involuntary. Retirement losses of lieutenant commanders occurring at LOS 20 and commanders occurring at LOS 26 are also assumed to be involuntary.

APPLICATIONS

The purpose of ORFM is to produce a set of loss rate forecasts, disaggregated by community, LOS, and pay grade over a 7-year horizon. Using the ORFM model, the manager is able to alter these forecasts either through the selection of one of the time-series techniques (MAD or HW) or through the imposition of a pay change. A pay change scenario requires the use of the COL module in ORFM.

In the initial implementation of ORFM, the manager is required to specify the pay change in terms of percent changes in basic pay relative to the most recent level of basic

pay. Thus, any changes in special pays and bonuses must first be translated into an equivalent change in basic pay. Moreover, the pay change must be stated in terms of percent changes net of inflation. This means that the manager must subtract an anticipated inflation rate from the pay change in order to state the change in terms of real dollars. The implicit assumption made here is that civilian pay will rise at the rate of inflation.

The pay change may be across-the-board, or community-, LOS-, or pay-grade-specific. If the manager does not enter a pay change for a particular cell, the model inputs a zero percent change, which implies an increase equivalent to the inflation rate (and civilian pay).

As an illustration of the capabilities of ORFM, consider three URL communities: submarine warfare, aviation warfare (pilot), and aviation warfare (naval flight officer or NFO). Figure 1 (a-c) plots the 1969 through 1981 fiscal year loss rates for submarine officers, pilots, and NFOs. For this illustration, the loss rates are not disaggregated by LOS or pay grade. Each figure includes the calculation of the mean loss rate, the number of times the loss rate crosses over the mean, the mean time between crossover, the coefficient of variation of loss rates, and the resulting period of wear-off used by ORFM. Because these calculations are central to the determination of the wear-off period, they require further consideration.

The history of loss rates for pilots is shown in Figure 1b. Between 1969 and 1981, the mean loss rate was 12.1 percent. Inspection of the plot of loss rates reveals that, during three periods--1972-1973, 1976-1977, and 1978-1979, the loss rate moved from below the mean to above the mean, or vice versa. The mean time between crossover is defined as:

$$\text{MEAN TIME BETWEEN CROSSOVER} = \frac{\text{TOTAL YEARS OF DATA}}{\text{NUMBER OF CROSSOVERS}}$$

In this example, the mean time between crossover is 4.3 years ($13/3 = 4.3$). The coefficient of variation of loss rates, which measures the volatility of the rates relative to the mean, is 0.173. Incidentally, this figure is relatively small compared to the coefficient of variation for submarine officers (0.231) and NFOs (0.296). This is an indication that pilot loss rates, at least when they are aggregated, are stable relative to the other officer communities. Based on these data, ORFM calculates a wear-off period for pilots of 4 years. Similar types of calculations may be made for submarine officers and NFOs.

Table 2 presents forecasts of 1982 loss rates using MAD regression and the HW technique. Four forecasts for HW are presented, which correspond to four different weights (100, 75, 50, and 25%) placed on the most recent year (i.e., 1981) of historical data. Note that, when 100 percent of the weight is placed on the most recent year, HW, in fact, becomes the naive time-series model; that is, the current period's (1982) forecast is equal to the last period's (1981) actual value. The actual 1982 loss rates are also presented.

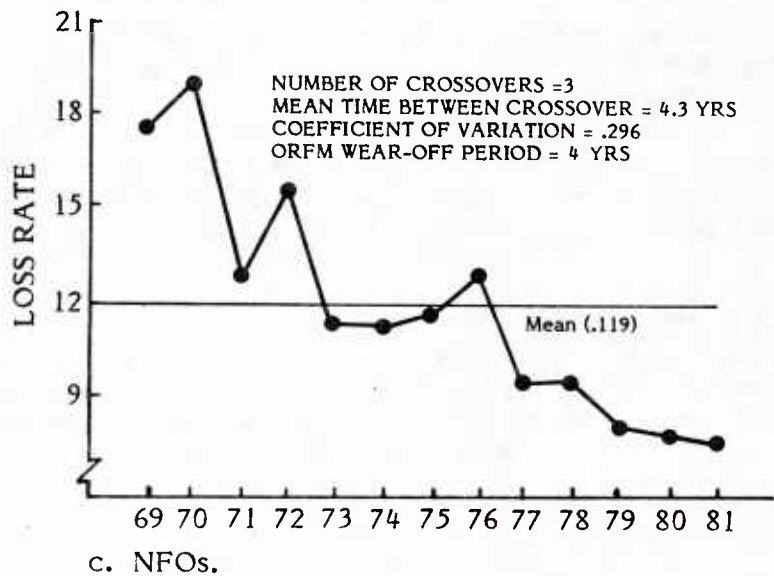
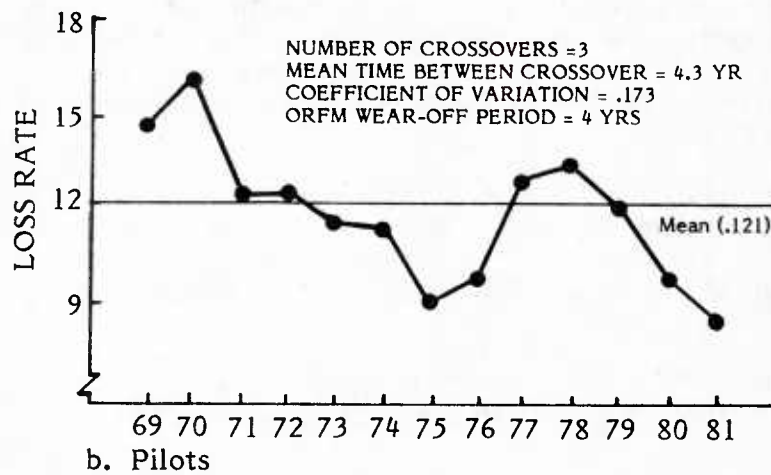
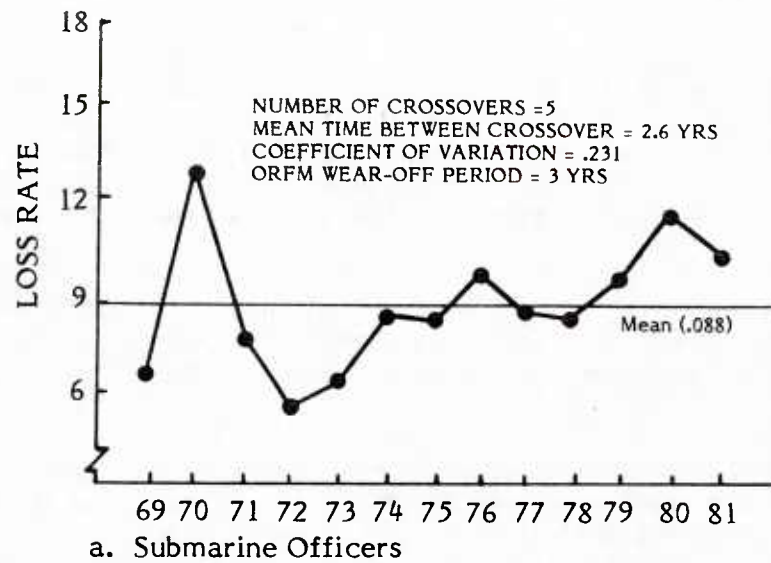


Figure 1. Loss rates (1969-1981) for three officer communities.

Table 2
Forecasts of 1982 Loss Rates Using MAD and the HW Technique
(B = Weight on Most Recent Yr, 1981)

Community	MAD	HW (B=1.0)	HW (B=.75)	HW (B=.50)	HW (B=.25)	Actual
Submarine	.076	.101	.099	.097	.093	.077
Pilot	.110	.086	.094	.103	.112	.043
NFO	.066	.078	.084	.093	.105	.066

The data indicate that 1982 loss rates declined substantially relative to 1981 (and earlier years). For example, the pilot loss rate declined from 0.086 in 1981 to 0.043 in 1982, a 50 percent drop. The MAD technique forecasts a significant decline in 1982 loss rates for submarine officers and NFOs but forecasts an increase for pilots. This finding, however, is not particularly surprising given the historically cyclical nature of pilot loss rates. Hence, MAD forecasts a trend reversal in pilot loss rates.

The decline in actual 1982 loss rates may, in part, be attributed to relatively high unemployment rates in the civilian economy. Moreover, basic pay and allowances for officers were increased by 14.3 percent in 1982. Since the inflation rate and civilian pay raises during calendar year 1982 were in the vicinity of 4 percent, officers received approximately a 10 percent increase in real pay. Thus, part of the decline in loss rates during 1982 may be related to the real increase in military compensation.

In addition to the increase in basic pay and allowances, many pilots and NFOs received the new aviation officer continuation pay (AOCP), which was designed to correct shortages in inventories in critical aviation specialties by paying continuation bonuses. In exchange for these payments, the officer agrees to remain on active duty for at least 1 year but no more than 4 years. However, to be eligible, the officer must have completed at least 6 but less than 16 years of aviation service. Moreover, the amount paid depends upon the officer pay grade, LOS, and the number of years of extension agreed upon. Therefore, it is not possible to determine a single number that describes the percentage increase in an equivalent amount of basic pay attributable to the AOCP. Of course, in the actual implementation of ORFM, it is possible to disaggregate this pay change by pay grade and LOS.

To consider in more detail how the effect of a pay change (and the wear-off function) is measured, assume that the average AOCP yearly payment is \$6768. Based on 1981 basic pay levels, this bonus payment is determined to be equivalent to a 23 percent increase in basic pay. If the actual inflation rate of 4 percent is subtracted and the 10 percent increase in across-the-board real pay is added, the total pay increase for pilots in 1982 is 29 percent. Note that, in a typical forecast situation, the actual inflation rate would not be known. Therefore, an anticipated inflation rate would be subtracted instead. Moreover, since the AOCP has been discontinued in 1983, those officers who signed 1-year contracts will, in effect, receive a pay decrease in 1983, while those who signed multiyear

contracts will be forced to remain on active duty. For the purposes of this illustration, these facts will be ignored although they are incorporated into the actual model.

Based on these data, and using 1981 as the base loss rate, ORFM predicts that the voluntary loss rate for pilots will decline from 0.058 in 1981 to 0.030 in 1982. Recall that the involuntary and community change loss rates must then be added to the predicted voluntary loss rate to obtain a prediction for the total loss. Assume that the total of the 1981 involuntary and community change loss rate, which is 0.028, will prevail into the future. Therefore, the projection of the total loss rate for pilots in 1982 is 0.058 (0.030 + 0.028).

Figure 2 presents a plot of this forecast and the derived linear wear-off function. Recall that, from the historical data, ORFM calculated a 4-year wear-off period for pilots. Moreover, the baseline to which loss rates migrate is a simple average of historical loss rates, which is 0.121. Therefore, the loss rate forecast increases by one-fourth of the difference between the first-year forecast (0.058) and the baseline (0.121) in years 1983, 1984, 1985, and 1986 and remains at the baseline in years 1987 and 1988. The wear-off is indicated by the dashed line in Figure 2.

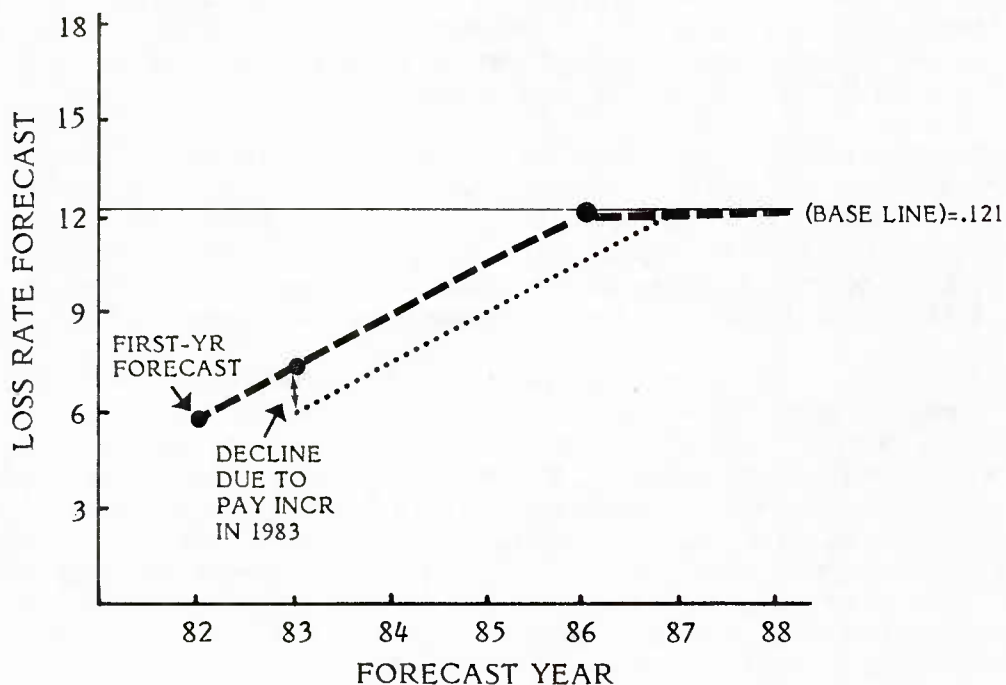


Figure 2. Loss rate forecasts (1982-1988) for pilots.

Suppose that, in addition to the pay increase in 1982, a 4-percent increase in real pay is realized in 1983. Recall that the procedure is to apply the wear-off function first and then capture the effect of the pay change. The 1983 loss rate forecast is 0.074 (0.058 + 0.25 (0.121 - 0.058)). ORFM predicts that the pay increase will cause the loss rate to decline to 0.061. Note that ORFM "restarts" the wear-off function after each new pay change. This new wear-off function is shown as a dotted line in Figure 2. Therefore, as a result of the 1983 pay increase, loss rate forecasts for 1983 to 1986 are below the forecasts without a 1983 pay increase.

CONCLUSIONS

ORFM is not a single model but, rather, a group of models intended to produce forecasts of loss rates over an extended period of time. Managers are provided with the capability to assess the effect of alternative compensation policies on forecasted loss rates. The model explicitly incorporates the concept of forecast uncertainty through use of a wear-off function. Most other military loss forecasting models have either ignored the issue of uncertainty or failed to integrate the concept explicitly into the forecasting framework.

Although the set of models that comprises ORFM is operational, further development is in process. Some areas of investigation include a nonlinear form of the wear-off function, a new methodology to calculate the baseline loss rate, the influence of civilian unemployment on loss behavior, and an empirical test of the absolute pay hypothesis. Officer loss behavior can be volatile and is subject to many external influences, posing particularly difficult forecasting problems, both theoretical and tactical. The development of future refinements in ORFM is intended to overcome some of these problems.

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